Radiation Safety Part 1

By David Provenzano, MD
President, Pain Diagnostics and Interventional Care
Pittsburgh, PA

Background

On November 8, 1895, a German physicist, Wilhelm Conrad Roentgen, discovered x-rays while working in his physics laboratory at Wurzburg University in Germany. In 1896, Thomas Edison created the first fluoroscope. This technology has undergone much advancement and has become integral to interventional pain procedures. In 2004, an estimated 4-10 million interventional pain procedures were performed in United States, with approximately 50% using fluoroscopy. This percentage has continued to grow over the last 6 years. Fluoroscopic guidance offers the ability to visually confirm the procedure area and dye spread and assists in the detection of unintentional intravascular injections.

Although we have been increasing our utilization of fluoroscopy, many individuals do not receive in-depth training on radiation safety. The ICRP (International Commission on Radiological Protection) states that many individuals are using fluoroscopy without being adequately trained in radiation safety or radiobiology. Interventional pain physicians must understand the concepts of radiation safety and how to apply this information to their practice to protect their health and that of their patients. For example, the FDA has received reports of interventional pain physicians receiving radiation skin injuries while placing spinal cord stimulators. Medical organizations also have recognized that many practitioners other than radiologists using fluoroscopy do not have adequate levels of education on radiation protection, and the ICRP has called for improvements in training.

As stated under the United States Nuclear Regulatory Commission's concept of the ALARA (As Low As Reasonably Achievable) Principle, there is no known absolutely safe dose of ionizing radiation. Physicians may have significant exposure to radiation secondary to cumulative effects of performing procedures for multiple years.

Most information on the biological effects of radiation has come from epidemiological studies of human populations that have been exposed to acute high-dose radiation such as the atomic bomb survivors at Hiroshima and Nagasaki and individuals near the Chernobyl power plant. The long-term adverse effects and biological consequences of cumulative exposure to low-dose radiation remain unclear. Furthermore the risk of developing cancer in people subject to low-dose ionizing radiation is debated and uncertain. It is imperative that individuals have a clear understanding of how to limit exposure levels while performing interventional pain procedures.

This continuing series will provide practitioners with information to understand radiation safety and to implement strategies for risk reduction. In the first part of this review we will focus on 10 facts to increase your understanding of radiation safety.

Best Practices: 10 Facts to Increase Understanding Of Radiation Safety

1. X-rays are a form of ionizing radiation which produce negatively and positively charged particles as they pass through matter. X-rays have a shorter wavelength than visible light.
2. Individuals utilizing fluoroscopy are exposed to secondary radiation (scatter and leakage) as long as they keep their bodies outside the primary beam. At one meter, the scattered exposure level is approximately 0.1% of the skin entrance exposure.
3. Units used to define the biological effects of radiation and enable calculations of effective *absorbed* dose are referred to as dose equivalents (DE). The sievert (Sv) is the SI unit and the rem (radiation equivalent man) is the traditional unit (TU) for DE. The rem is the unit utilized on the radiation dosimetry report. 1 rem = 0.01 Sv.
4. Initially, the National Council on Radiation Protection and Measurements (NCRP) described the maximal permissible dose (MPD) for occupational exposure. Although MPDs are often listed in textbooks, the terminology has been replaced by the effective dose equivalent (EDE) limiting system in order to indicate that "no dose is considered permissible." According to the NCRP, adherence to these limits ensures that lifetime risk from radiation exposure remains acceptable, not negligible.
5. Individuals preferably should not receive more than 10% of the EDE limits annually. An occupational worker's lifetime effective dose should be limited to his or her age in years times 1 rem. Malignancy may occur at low doses.
6. Stochastic (probabilistic) and nonstochastic (deterministic) are the two subdivisions of the biological effects of radiation exposure.
7. Stochastic effects are non-threshold, randomly occurring biological effects of ionizing radiation. The probability, not the severity, of a stochastic effect increases with higher doses of ionizing radiation. Examples of stochastic effects are cancer and genetic changes.
8. Nonstochastic effects have a threshold dose that has to be exceeded in order for the effect to occur. Once this threshold dose is exceeded, the effect will occur and the severity will increase with higher radiation doses. The radiation doses required to cause nonstochastic effects should not be exceeded during routine interventional pain procedures as long as appropriate safety measures are followed. Examples of nonstochastic effects are cataract formation, skin burns, and hair loss.
9. Organ damage including cataracts (200 rad) and skin erythema (500 rad) can occur from acute radiation exposure. Greater than 10 minutes of continuous fluoroscopy in the

boost mode is needed to achieve these levels. These doses should not be exceeded during performance of interventional pain procedures.

10. Cataracts can also be induced with larger doses over a fractionated regimen.

References

1. Hirshfeld JW, Jr, Balter S, Brinker JA, Kern MJ, Klein LW, Lindsay BD, et al. ACCF/AHA/HRS/SCAI clinical competence statement on physician knowledge to optimize patient safety and image quality in fluoroscopically guided invasive cardiovascular procedures: a report of the American College of Cardiology Foundation/American Heart Association/American College of Physicians Task Force on Clinical Competence and Training. *Circulation.* 2005 Feb 1;111(4):511-532.
2. Rathmell JP. Atlas of Image-Guided Intervention. Philadelphia,PA: Lippincott Williams & Wilkins; 2006.
3. Valentin J. Avoidance of radiation injuries from medical interventional procedures. *Ann.ICRP* 2000;30(2):7-67.